Using Personnel Records to Model Longitudinal Exposures of Pesticide Applicators Exposed to a Soil Fumigant

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Abstract

One of the difficulties in modeling long-term exposure in pesticide workers is the limited availability of longitudinal data on the exposure-related factors for individual workers. One solution is to use data collected for economic reasons (time sheets, payroll records, or other work records). An example of how such data can be used is developed for 47 workers at a pesticide application company who apply a pesticide (a soil fumigant). For this pesticide, the key route of exposure is inhalation and the relevant measure of exposure is the 24-hour TWA air concentration (ppb). The data available for the workers consist of 1) the number of acres treated in a given month for each of 47 workers over a 12-month period, 2) data on the variation in air concentrations associated with various tasks that make up the standard workday, and 3) information on the typical durations for the tasks during a work day. Using these data a Monte Carlo model of each workers' longitudinal exposures over a one year period were prepared. Using this model, distributions of 24-hour TWA air concentrations were prepared for 1-, 7-, 30-, 90- and 365-day averaging periods. These distributions reflect variability in frequency of exposure, variability in levels of airborne concentrations, and the uncertainty due to the lack of data on the specific days (during each month) when the workers used the product. The medians of the resulting distributions ranged from 0.9 ppb for 1-day measurements to 0.01 ppb for 365-day averages. The dose at the 95th percentiles ranged from 0.2 ppb for 1-day measurements to 0.03 ppb for 365-day averages.

Acres Treated

Driver code	May		June		July		August		September		October		November		December		January		February		March		April			
	Tarped	Non-Tarped	Tarped	Non-Tarped	Tarped	Non-Tarped	Tarped	Non-Tarped	Tarped	Non-Tarped	Tarped	Non-Tarped	Tarped	Non-Tarped	Tarped	Non-Tarped	Tarped	Non-Tarped	Tarped	Non-Tarped	Tarped	Non-Tarped	Tarped	Non-Tarped	Total Tarped	Total Non-tarped
1				1		11				24		54		206		66		69		35		63		4	0	521
2			8	6	12		148		102		197		9				11				37		23		545	6
3	3		105		67		94		203		203		47		3						10		116		777	0
4	6		0		27		48	13	174	28	88	222		74							23		74		441	336
5	26				24		177		173		263		19		4	57					22		27		683	57
6				292		114		136		229		272		236	81			92		18	1	64		38	82	1489
7	10		7		23		47		122	28	105	190	9	30	5						23		105		496	247
8	49		20		151		207		331		241		60	36	17	50	28		3		114		53		1364	86
9	12	14	9		41		60		98		271	11	59	1			8				23		117		706	26
10	4		1		12		12		62		75		53		9		13				49		62		332	0
11			10		70		16	143	36	1	43	118	21	52	6	53	28		10		111	4	37		378	390
12				10			96		64		104	265	20	10					9						293	275
13						13		5																	0	18
14	40		36	6	41		44		374		197	34	30								17		47		727	43
15	71		23		41		49	6	306		201		21	162		174		37		67	48	30	49	72	806	639
16					36		102		90		221	16	6								1		10		463	15
17	37		13		36		156		167		227		43				8	30			39		27	6	753	34
18					49		55		135		175		17			20	6	46			3	12		22	440	100
19	12		117		99		98		203		24		18		3		5				6		29		613	0
20					39		160		107		226		10	12							2			10	544	22
21					79		123		107		100		5		47		7	8			91		66		624	8
22		24					106		80		181		32										12	177	490	203
23		26			15		161		149		223		24												573	26
24			11		38		84		241		196		15								20		5		609	0
25									0			7												1	0	8
26	48		29		3		71		165	76	236		44	2							29	16	60	10	689	102
27	40		36		68		51		235		366		18	10		30	76		76	28	4	7	15	778	171
28				1		20			0																0	21
29		35			16		102		164		152	2	13	97		29		304		30		63		264	447	625
30																									1	0
31	7		3		72		164		106		205	38	12		23						65		100		757	38
32							0			107		169		40											4	316
33	1		13		13		137		128		174		26			120		230			13			79	462	442
34							175		216		166	0	110								3				670	0
35	33				128		96	29	229		296	6	63	32		149	69	56	35	3	78	17	108		1143	292
36	3		134		116		162		112		217	23	67	6	22		18		9		49	20	49		957	49
37	22						0																		22	0
38							0																37	45	37	45
39	43		119		86		212		224		141		40				31				66		1		962	0
40				54	118	13	149	3	244		316	21	43	164		49	35	8	35		58	42	1		999	373
41			9		46	43	102	13	240		344	6	62		65		67		11		47	4	51		945	66
42				292	0			200		214	1	371		121		187		133			3	36		29	5	1564
43				21	0								4												4	21
44							65		77		166														308	0
45					28	71	51	114	117		208	26	95	1	107	30	62		75	2	94				264	826
46							67	67			219	22	23												22	336
47	21		3	42	104		74		181		121			24							57		80		646	42
Total	487	99	793	782	1653	215	3629	638	5469	887	6376	2234	1055	1414	321	1061	388	1139	181	313	1126	482	1332	772	22691	9956

Approach

In California, a volatile soil fumigant is applied by licensed pesticide applicators using tractor-drawn injection plows. The applicators go from farm-to-farm treating the soil. Because of California's temperate climate, soil fumigation occurs throughout the year resulting in both acute and chronic exposures to the applicators. Longitudinal data on the workers was available in the form of payroll records for 47 individual workers. These work records consisted of the number of acres treated each month using tarped and non-tarped applications from April 1997 to March 1998, Table 1. Based on interviewed workers, a typical day consists of set up 1.5 hrs, 5.5 hrs of application, 1 hr for lunch and 1 hr for cleanup. The the average area treated per hour was reported to be 2.4 acres/hr for tarped applications and 4 acres/hr for non-tarped applications. Using these data, estimates were made for the number of days worked for each of the 12 month (partial days were rounded up), Table 2 and Figure 1.

A model of each worker's daily work history for the 12-month period was simulated using a Monte Carlo model of the work status (work/nonworking) on each of the 365 days of the period. The simulation was created using @Risk™ an Excel™ software add on program. Each day was modeled using a binary model where the probability of working for an individual on a given month is that individual's number of work-days for that month divided by the number of days in the month. If an individual was determined to work, a 24 hr TWA air concentration was calculated using the following equation:

$$AC_{1\text{-day, TWA}} = \sum AC_i * AD_i$$

where,

$AC_{1\text{-day, TWA}}$ is the 1-day 24-hour time weighted average air concentration (ppb)

AC_i is the air concentration during the i^{th} activity (ppb), and

AD_i is the duration of the i^{th} activity (hr).

In this model there are three activities, set up, application, and lunch/cleanup. Table 3 gives the values for AC_i for these activities. The values were based on a monitoring survey that consisted of 8 air samples in the tractor during application (used for application) and 9 area samples (used for lunch/cleanup). The air concntration during sep up was assumed to be zero. Each value is sampled using a discrete uniform distribution. The values of AC_i on a given day were assumed to be independent.

Once the daily exposures were determined, 7-day, 30-day, 90-day average values were determined for the respective 356, 335, and 275 sets of contiguous days for the 47 individuals. The annual averages are also determined. These values were randomly sampled to produce a distribution of 1-day, 7-day, 30-day, 90-day, and annual averages. These sampled reflect both inter- and intra-individual variation in 1-day, 7-day, 30-day, 90-day, and annual average daily exposures. Values that were zero were discarded.

The process was repeated 5,000 times. The resulting distributions can be thought of as a random sampling of any one of the 47 individuals on any day or any set of n-contiguous days of the year where the pesticide was applied on one or more of the days. Figure 2 presents the cumulative distribution for the different averaging periods. As would be expected as the averaging period increased from 1 day to annual the average exposure declined. The medians of the exposures ranged from 0.09 ppb to 0.01 ppb and the upper bounds of the exposures (95th percentiles) ranged from 0.2 ppb to 0.03 ppb.

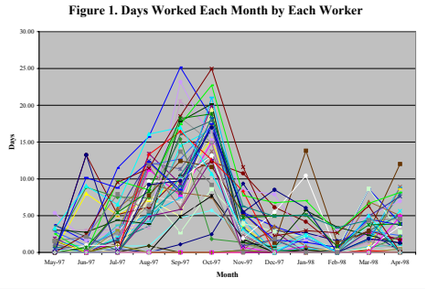
Discussion and Conclusions

This effort is intended to be a demonstration of how minimal longitudinal data on worker exposure can be used to model longitudinal exposures. There are a number of additional issues that should be explored in an actual assessment worker exposures. These include the impact of auto correlation, consideration of week day versus week end days when modeling the probability of working, and incorporation of seasonal and day-to-day variation in the length of the work days. However, the work demonstrates that data collected for economic reasons (payroll) can provide a basis for longitudinal exposure modeling. In this instance, the upper range of acute exposure (1-day) were found to be 7 fold higher then chronic exposures (annual average).

Total Days By Month

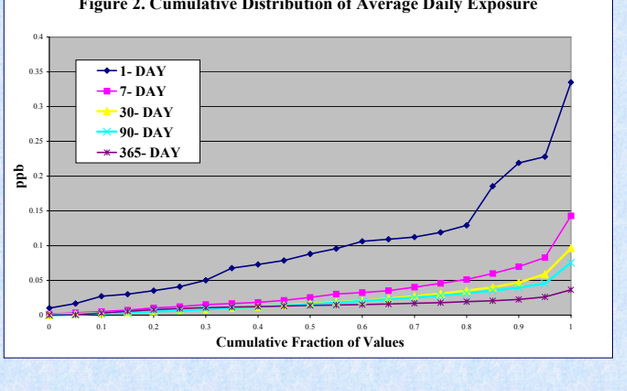
Driver	May-97	Jun-97	Jul-97	Aug-97	Sep-97	Oct-97	Nov-97	Dec-97	Jan-98	Feb-98	Mar-98	Apr-98	Min	Max	Average
1	0	0	0	0	1	2	1	0	3	2	3	0	0	9	2
2	0	1	1	11	8	15	1	0	1	0	3	2	0	15	3
3	0	8	5	7	10	15	4	0	0	0	1	9	0	15	5
4	0	0	2	4	14	17	3	0	0	0	2	6	0	17	4
5	2	0	2	13	9	20	1	3	0	0	2	2	0	20	5
6	0	13	5	6	10	12	11	6	4	1	3	2	0	13	6
7	1	1	2	4	11	17	2	0	0	0	2	6	0	17	4
8	4	2	11	16	25	18	5	4	2	0	9	4	0	25	8
9	2	1	3	5	7	21	4	0	1	0	2	9	0	21	5
10	0	0	1	1	5	6	3	1	1	0	4	5	0	6	2
11	0	1	5	8	3	9	4	3	2	0	9	3	0	9	4
12	0	0	0	7	5	19	2	0	0	1	0	0	0	19	3
13	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0
14	3	3	3	3	21	17	2	0	0	0	1	4	0	21	5
15	5	2	3	4	23	15	8	8	2	3	5	7	2	23	7
16	0	0	3	8	7	17	0	0	0	0	1	0	0	17	3
17	3	1	3	12	13	17	3	0	2	0	3	2	0	17	5
18	0	0	4	4	10	13	1	1	3	0	1	1	0	13	3
19	1	0	7	7	15	2	1	0	0	0	0	2	0	15	4
20	0	0	3	12	8	17	1	0	0	0	0	0	0	17	4
21	0	0	6	9	8	8	0	4	1	0	7	5	0	9	4
22	1	0	0	12	6	14	2	0	0	0	0	9	0	14	4
23	1	0	1	12	11	17	2	0	0	0	0	0	0	17	4
24	0	1	3	6	18	15	1	0	0	0	2	0	0	18	4
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	4	2	0	5	16	18	3	0	0	0	3	5	0	18	5
27	3	3	4	4	18	20	1	1	6	3	2	1	1	20	6
28	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
29	2	0	1	8	12	5	1	14	1	3	12	0	0	14	6
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	1	0	5	12	8	17	1	2	0	0	5	8	0	17	5
32	0	0	0	0	8	8	2	0	0	0	0	0	0	8	1
33	0	1	1	10	10	13	2	5	10	0	1	4	0	13	5
34	0	0	0	13	16	13	8	0	0	0	0	0	0	16	4
35	3	0	10	9	17	23	8	7	7	3	7	8	0	23	8
36	0	10	9	12	8	17	5	2	1	1	5	4	0	17	6
37	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	3	9	7	16	17	11	3	0	2	0	5	0	0	17	6
40	0	2	10	11	19	25	12	2	3	3	6	0	0	25	8
41	0	1	5	8	18	19	5	5	5	1	4	4	0	19	6
42	0	13	0	9	10	17	5	9	6	0	2	1	0	17	6
43	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
44	0	0	0	1	5	6	13	0	0	0	0	0	0	13	2
45	0	0	0	6	7	9	18	6	5	3	4	0	0	18	5
46	0	0	0	0	3	10	3	0	0	0	0	0	0	10	1
47	2	2	8	6	14	9	0	2	0	0	4	5	0	14	4

Figure 1. Days Worked Each Month by Each Worker



Reported Montoring Data (ppm)			
Sample	Set-up	Drivers Air conc.	Lunch and Takedown
1	0	0.903	0.459
2		ND	0.337
3		0.423	0.184
4		0.052	0.366
5		0.251	1.536
6		0.245	0.146
7		0.087	0.252
8		0.397	0.201
9			0.122
ND: Non detect			

Figure 2. Cumulative Distribution of Average Daily Exposure



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